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The Biology of the Sandbar Shark Carcharhinus plumbeus (Nardo, 1827) in the Lower Chesapeake Bay and Adjacent Waters

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THE BIOLOGY OF THE SANDBAR SHARK *CARCHARHINUS PLUMBEUS* (NARDO, 1827) IN THE LOWER CHESAPEAKE BAY AND ADJACENT WATERS

A Thesis

Presented to

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The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

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by

Edward Fenton Lawler Jr.

1976

APPROVAL SHEET

This thesis is submitted in partial fulfillment of
the requirements for the degree of

Master of Arts

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ABSTRACT

Carcharhinus plumbeus and *C. obscurus* are the two most abundant species of sharks found in the lower Chesapeake Bay and adjacent waters from early summer to late fall.

Both species segregate by size with the smallest *C. plumbeus* being found inside the Bay, the smallest *C. obscurus* found off the mouth of the Bay and larger individuals of both species being found further offshore.

Age and growth of females determined by vertebral sectioning and staining indicate that both *C. plumbeus* and *C. obscurus* are long lived species attaining at least 18 years for the former and 28 years for the latter. Minimum age of sexual maturity was 15-16 years for *C. plumbeus* and 23-26 years for *C. obscurus*.

Stomach analysis indicates *C. plumbeus* and *C. obscurus* feed on fishes and larger invertebrates from the epibenthic community.

THE BIOLOGY OF THE SANDBAR SHARK

CARCHARHINUS PLUMBEUS (NARDO, 1827) IN THE

LOWER CHESAPEAKE BAY AND ADJACENT WATERS

INTRODUCTION

Carcharhinus plumbeus, the sandbar shark, is a large Carcharhinid shark found in the three major oceans and the Mediterranean Sea (Bass, D'Aubrey and Kistnassamy, 1973). The shark is common off the Hawaiian Islands (Wass, 1973) in the East China Sea (Taniuchi, 1971) and in Western North Atlantic (Springer, 1960).

The Western North Atlantic population of C. plumbeus (= C. milberti, see Bass et al, 1973) ranges from Cape Cod, Massachusetts to West Palm Beach, Florida in summer and from the Carolinas to the Gulf Coast of Florida in winter. It is found in coastal bays and inlets and offshore to a depth of about 200 meters during summer (Springer, 1960). Size, growth and reproduction of C. plumbeus in Hawaiian waters (Wass, 1973), reproductive biology in the East China Sea (Taniuchi, 1971), size, distribution, feeding and reproductive biology on the East Coast of South Africa (Bass, et al, 1973) and Springer's (1960) account of the natural history of the species in the Western North Atlantic, Caribbean, and Gulf of Mexico represent the major contributions to the life history of C. plumbeus.

Hildebrand and Schroeder (1928) considered C. plumbeus a rare visitor to the Chesapeake Bay but a recent account lists it as common to abundant in summer (Musick, 1972). *Carcharhinus obscurus* (Lesueur, 1818) is the second most common shark in the study area and is common in the Western North Atlantic from Cape Cod to Florida. The capture of *C. obscurus* at Cape Henry establishes a new Bay record. Age-growth, food habits, size and sex ratios, seasonality and distribution of *C. plumbeus* and *C. obscurus* in the lower Chesapeake Bay and adjacent waters are presented herein along with observations on the less common sharks captured during the research (Appendix A).

MATERIALS AND METHODS

Sharks examined were collected by longline or commercial haul-seines. The longline technique provided the majority of the study specimen. This gear had four to six meter gangions and #40 recurved steel hooks. Average number of hooks set was 39 and bait was collected by a thirty-foot semi-balloon benthic trawl in the vicinity of the longline set (except for stations 4 and 5 where bait from inshore trawls was used). Sets were usually of four to six hour duration and surface water temperature was taken after each set. Haul-seines fished in the Chesapeake Bay and along the Virginia coast from Sandbridge to False Cape provided late fall specimens (Fig. 1).

Longline sets were made from early spring to late fall from the R/V Pathfinder (Virginia Institute of Marine Science) in five localities: vicinity of Cape Charles and Kiptopeke(1); Cape Henry(2); within 4 km of Virginia Beach, Va.(3); vicinity of Chesapeake Light Tower (36°54' north and 75°42' west)(4); and the Triangle Wrecks (37°00' north and 75°22' west)(5) (Fig. 1).

All specimens were identified and measured; also weights were determined when possible. Total length was determined by the formula: total length = standard length + 0.8 (upper caudal length) after Bass et al (1973) where standard length was the straight line distance from the tip of snout to the upper caudal pit. Stomach contents were identified to species when possible. State of maturation was determined in females by macroscopic examination of uteri. Immature females had constricted uteri which were closely associated with the dorsal surface of the abdominal cavity. Males were considered mature if the claspers were highly calcified and extended beyond the posterior margin of the pelvic fins. External parasites were preserved in Davidson's fixative and later identified.

Vertebrae were excised for age determination from the region anterior to the first dorsal fin and included the fifteenth through twentieth vertebrae which were of uniform size. Preparation of vertebrae included techniques used by Casey, Stillwell and Pratt (pers. comm.) on C. plumbeus and by Stevens (1975) on the blue shark, Prionace glauca. Vertebrae, which had been preserved in 10% buffered formalin, were rinsed in water and stored in 70% ethanol. One vertebra was selected and cut sagitally with a coping saw through the center, resulting in a block with an hourglass shaped face. The face was then polished using a hone glass compound and water on a plate of frosted glass. The vertebra was then washed in deionized water and placed in a 1% solution of silver nitrate; while immersed it was illuminated by ultraviolet light until the face turned dark brown. The vertebra was then rinsed a second time in deionized water and polished to remove excess stain. In this way darkly stained rings were enhanced. These rings were composed mainly of inorganic salts and were separated by a thin light band dense in proteinaceous material (Stevens, 1975). The lighter bands were designated as the unit of aging. Measurements of vertebral rings and radii were made from the apex of the dorsal and ventral halves of the vertebra (where notochordal elements were visible) along an oblique line that followed the inner edge of the face. All measurements were made with a dissecting scope equipped with an occular micrometer.

Data for longline sets in 1974 and 1975 were pooled to obtain the average monthly values for surface temperature, total catch per unit effort (CPE), CPE for C. plumbeus and C. obscurus, number of species per hook, and Margalef's index of species richness (D). The value for CPE was defined as: No. of sharks captured/No. of hooks set. Margalefs index D was defined as $\frac{s-1}{\log_e N}$, where s = total number of species and N = total number of individuals. Histograms representing the size ranges of C. plumbeus and C. obscurus at each station also contained the pooled 1974 and 1975 data.

Computation of growth increments and von Bertalanffy growth equations followed Ricker (1975). Statistical regressions were calculated to describe length-weight relationships and to determine intercept values for back calculations (Snedecor and Cochran, 1972). Calculations were performed on an IBM 370-115 computer utilizing programs from the computer library of the Virginia Institute of Marine Science (VIMS).

RESULTS

Seasonal distribution

The average monthly surface water temperatures for all stations in 1974 and 1975 where sharks were captured ranged from 15.4 to 27 C. Early spring catches (associated with the lowest temperatures) consisted of Mustelus canis and Squalus acanthias. Carcharhinus plumbeus and C. obscurus were first captured when surface temperatures averaged 18.9 C and were last taken in the fall when the temperatures averaged 18.4 C (Fig. 2, Table 1).

Rhizoprionodon terranovae, C. limbatus, C. falciformis, Galeocerdo cuvieri, Sphyrna leweni, Odontaspis taurus, Mustelus canis, and Squalus acanthias were also captured in 1974-1975 longline sets.

Total catch per unit effort rose from .1 in June to .4 in September. The latter is attributed in part to a catch of 32 C. plumbeus at stations 1 and 2 (Fig. 3 and Table 1). Maximum CPE values for C. plumbeus (0.3) and C. obscurus (.035) were obtained in late summer (Fig. 2).

Number of species per hook rose from May (0.01) through October (0.04) (Fig. 3). Margalef's index D was highest in July (3.9) and remained above 2.5 through October. The decrease in D in September was attributable to the above mentioned catches of C. plumbeus in September 1975 (Fig. 4, Table 1).

Carcharhinus plumbeus and C. obscurus segregated by size with the smallest individuals captured at inshore sites (Figs. 5 and 6). Pregnant and post partum females were captured at both inshore and offshore sites (Figs. 5 and 6).

Age and growth

Vertebrae from ninety-six C. plumbeus (83 females and 13 males), and twenty C. obscurus (13 females and 7 males) were examined for age analysis.

Carcharhinus plumbeus is apparently a long lived species with females attaining at least eighteen years (Figs 7 and 8). Vertebrae from full term embryos (born on deck and surviving three days in a holding tank) to mature females were examined and included males up to maximum sizes of 106 cm TL, 9kg, and aged to seven years. The largest female C. plumbeus was 207 cm TL and 70kg in weight. Length and weight of males did not differ from that of females in the year classes encountered. The weight (y) - length (x) expression for C. plumbeus was log y = 1.7 + .325 log (x) (Fig. 9). The relationship of total length (y) and vertebral radius (x) was linear for male and female C. plumbeus (y = -10.4 + .658 x, (r = .979) for males; and y = -3.5 + .596 x (r = .986) for females). The intercept value for females was used as a correction factor in back calculations. Mean back calculated lengths were used to estimate growth parameters. Back calculated lengths at a given age for female C. plumbeus were within the observed range of total lengths at that age in eleven of the sixteen age groups represented by more than one individual (Table 2). The smallest mature female was 173 cm and was captured in 1976 but vertebrae were not taken. Back calculations based on aged sharks would thus fix the minimum age of maturity at sixteen years for females.

A Walford plot was used to determine the asymtotic length in the von Bertalanffy equation. The expression calculated for female C. plumbeus was $l_t = 267\ (1-e^{.05682\ (t+\ 2.8569)})$. An insufficient size range and sample size precluded calculations of the von Bertalanffy expression for males.

The smallest free swimming C. plumbeus was a male 54.5 cm TL, 1.1 kg, and the largest immature female was 179 cm TL and 44 kg.

Age determination of C. obscurus was based on females from a much smaller sample size and included a greater size range of an apparently longer-lived species (28 years - Figs. 10 & 11) compared to C. plumbeus. The relationship of total length (y) and vertebral radius (x) for female C. obscurus was $y = -1.62 + .067\ (x)$ ($r = .996$). Age groups I and II were the only groups represented by more than one individual while age groups VII, VIII, XII, XIV, XXIII, and XXVIII were represented by single specimens (Table 3). The smallest mature female C. obscurus was 315.9 cm TL, 255 kg and vertebrae indicated the specimen to be twenty-three years old. Back calculations yield an estimate of twenty-five to twenty-six years if the same total length was used. The weight (y) - length (x) expression for C. obscurus was log y = 1.7 + .310 log (x) (Fig. 12). A Walford plot was used to determine the asymptotic length in the von Bertalanffy equation. The von Bertalanffy expression for female C. obscurus was $l_t = 859\ (1-e^{.01432\ (t+\ 6.7012)})$.

Carcharhinus plumbeus and C. obscurus were not available over the entire year but the greatest vertebral growth increments were noted in sharks collected in the fall. Annulus formation was assumed to occur in late fall when the summer fauna migrates southward (Casey, 1976).

The smallest free swimming C. obscurus was a male 81.3 cm TL and 5.4 kg, and the largest immature female was 233 cm and 80 kg.

Embryo length-weight relationships are presented for two litters each of C. plumbeus and C. obscurus (Fig. 13). Only two embryos were recovered from the 1974 female C. plumbeus. She had aborted an undetermined number while alongside the vessel. All specimens from the C. obscurus litters had lunate upper caudal lobes indicating that they were not yet full term.

Food habits

C. plumbeus and C. obscurus feed mostly on epibenthic fishes. Percent occurrence of prey items approximated their relative abundance in the study area, based on observations of the composition of the fauna captured in a 30' otter trawl used to obtain bait for the longline sets.

Of 162 stomachs of C. plumbeus examined, 100 (62%) were empty. A list of prey items and percent occurrence is presented in Table 4. The occurrence of eelgrass Zostera marina in two stomachs and Nassarius trivetattus (Neogastropoda) in five stomachs suggests they were incidental prey items encountered while foraging on the bottom. Food habit data of C. obscurus is from 39 stomachs of which 22 (56%) were empty (Table 5).

Parasites

Ectoparasites collected from C. plumbeus and C. obscurus are discussed in this section whereas those from other shark species are noted in appendix A.

The copepod Pandarus floridanus was taken from the pectoral and pelvic fins and nares on C. plumbeus and represents a new host record. Other pandarid species that were occasionally found on large C. plumbeus were P. smithi (pectorals and dorsal surface), and Perrissopus dentatus.

A marine leech of the family Piscicolidae (Stilarobdella macrothela) was found on two occasions attached to the anal fin of mature female *C. plumbeus*. This establishes a new host and Virginia record (Sawyer et al, 1975).

Parasitic copepods attached to the pectoral fins of *C. obscurus* were *Alebion carcharidae* (Euryphoridae) and *Pandarus smithi* (Pandaridae).

Abnormalities

Two female *C. plumbeus* were captured with obvious cranial deformities (Fig. 14). The first specimen, VIMS Lot No. 03558, captured at Cape Henry in 1974 measured 80.4 cm TL and 7.9 kg. The second specimen captured at Kiptopeke in 1975 measured approximately 95 cm TL and 5.2 kg. Both specimens had a shortened, blunt snout, which at first appeared to be caused by an earlier injury. Closer inspection showed no damage to the nares, and the snout had the crypts of Lorenzini intact although their configuration was somewhat altered due to the up-turned shape of the snout. The two specimens appeared healthy and normal in every other aspect.

DISCUSSION

Seasonal distribution

The faunal composition of sharks in the Chesapeake Bay and Coastal Virginia waters changes seasonally with different species predominating in summer and winter. *Carcharhinus plumbeus* and *C. obscurus* are the dominant members of the summer fauna and are present over the longest time period (May - October, Table 1).

Weather conditions prevented longline sets in November but *C. plumbeus* and *C. obscurus* were captured by haul seiners at False Cape at that time. Size distribution of these sharks was more heterogenous than the late summer longline catches at the Virginia Beach station. Tags returned from two individuals that I released at False Cape in November 1976 indicated the sharks captured in beach seines were migrating south (Casey, 1976).

Other sharks captured on longline included species of the tropical, temperate, and boreal fauna.

Rhizoprionodon terranovae was captured from June through October (July record reported in 1976) with the greatest number (9) caught in September. *Carcharhinus limbatus* reached peak abundance in August when eleven specimens were captured. *Carcharhinus falciformis* was caught only in October (eight specimens). Seven specimens of *Galeocerdo cuvieri* were captured: (2) in July and (5) in August. *Sphyrna leweni* was captured from July through October with two being the greatest number taken in any month (August). One specimen (VIMS 03615) was the first documented record for the Chesapeake Bay. In addition, *C. lucas* and *Negaprion brevirostris* which had been absent from 1974-1975 longline sets were captured in a set off Fisherman's Island during July, 1976. *Carcharhinus leucas* has been reported from the upper Bay by Schwartz (1959, 1960) and *N. brevirostris* has been reported from Virginia's seaside bays in summer by Hoese (1962). These species are tropical-subtropical and migrate to the northern latitudes in the summer as water temperatures become more favorable (Bigelow and Schroeder, 1948). These species are tropical-subtropical and migrate to the northern latitudes in the summer as water temperatures become more favorable.

Odontaspis taurus, captured from June through September, is a temperate shoal water species which usually goes no deeper than five fathoms (Bigelow and Schroeder, 1948). The wintering range is not known for the Western North Atlantic population but it is the most common large shark taken in the fall by haul-seines along the Virginia coast and occasional captures were noted until January. *Mustelus canis*, another temperate species (Bigelow and Schroeder, 1948), was captured in April (8), May (6), and July (1). It winters primarily to the south of Chesapeake Bight and the summer population is most abundant from Delaware Bay north (Davis, 1969).

One _Squalus acanthias_, a boreal species (Bigelow and Schroeder, 1948), was captured in May. This was the most abundant and almost singular member of the winter shark fauna in the study area as witnessed from haul seine catches. It is extremely abundant during winter in the Chesapeake Bight but is virtually absent in the summer when it migrates to more northern latitudes (Musick and McEachran, 1969).

Total CPE appears directly related to the seasonal temperature trend from June through October and is primarily influenced by the relative numbers of _C. plumbeus_ captured. The declining CPE trend from April to June (Fig. 3) is due to the general exodus to the north of _M. canis_ which was the dominant species in April and May. The CPE profiles for _C. plumbeus_ and _C. obscurus_ appear correlated with seasonal temperature changes except for _C. obscurus_ in October. This may be attributed to northerly parts of the population of _C. obscurus_ migrating south into our area or perhaps is an artifact of the sampling gear or small sample size of _C. obscurus_.

Most sharks captured were tropical or sub-tropical and tend to migrate to northern latitudes as temperatures become compatible (Bigelow & Schroeder, 1948). Species per hook data reflect "pulses" of the different species as they enter the area throughout the summer and fall.

Species richness (D) demonstrates this pattern also, but the effect of total number of sharks on the index (D) results in a slightly different curve than for species per hook (Figs. 3 & 4). The high "D" value in October probably reflects a drop in abundance of the common species (*C. plumbeus*) triggered by the drop in temperature (Figs. 2 and 4).

Age and growth

Various authors (Ishiyama, 1951; Parker and Stott, 1965; Daiber, 1960; Taylor and Holden, 1964; and Stevens, 1975) have demonstrated vertebral ring calcification in elasmobranch species and have had varying degrees of success in ascertaining the validity of the rings as annuli. Vertebrae from *C. plumbeus* and *C. obscurus* females were obtained over a large size range and the aging techniques of Stevens (1975) worked well. Correlation of total lengths with vertebral radii and back calculated lengths with observed lengths suggest that growth checks designated on the vertebrae were valid annuli. The average back calculated values in age groups I and II of *C. plumbeus* were lower than the observed length ranges and suggest a gear selectivity for larger individuals. This phenomenon was not found in comparable age classes of the much larger *C. obscurus*. Preliminary tag return data (Casey, 1976) indicate that *C. plumbeus* lives for at least ten years and has a mean annual growth rate of 2.5 cm per year for juveniles and 1.25 cm per year for adults. This is a considerably lower estimate than herein reported for either C. plumbeus or C. obscurus (Tables 2 and 3) and may be attributed in part to the inherent variability of data from a cooperative tagging program.

Springer (1960) suggested that C. plumbeus matures two to three years after birth but he did not have aging data to support this. Wass (1973) estimated growth to maturity of C. plumbeus in Hawaiian waters by two methods: first, specimens held in captivity from four to thirty months yielded an estimate of three years; second, the number and rate of tooth replacement gave an estimate of thirteen years for females and ten years for males.

Sizes at maturity for Western North Atlantic populations of C. plumbeus were close to that reported by Springer (1960) but were greater than those reported by Wass for C. plumbeus. Hawaiian C. plumbeus are tropical and do not migrate. Wass suggested actual size at maturity to be somewhere between the two estimates.

The Western North Atlantic population is found from the tropic to temperate regions and undergoes extensive seasonal migrations (Springer, 1960). Populations of other eurythermal fish species from warmer regions may grow faster, mature at a smaller size and be shorter lived than populations from colder regions (Brett, 1970 and Garside, 1966).

Stevens (1975) generated a growth curve from vertebrae that spanned twenty years for _P. glauca_. His results are similar to my estimates for _C. plumbeus_ and _C. obscurus_ in that both suggest large carcharhinids grow at a relatively slow rate and live to be quite old.

Time and place of pupping of _C. plumbeus_ and size of pups at birth agrees with Springer (1960), who reported that the primary nursery grounds lie in shallow coastal waters of less than twenty fathoms between Cape Cod, Mass. and Cape Kennedy, Fla. Females pup in the summer and have an average litter size of nine. Length at birth was reported as 22 to 23 inches (55-57 cm).

Food habits of _C. plumbeus_ agree with those reported by Bigelow and Schroeder (1948), Dalhberg and Heard (1969), Clark and von Schmidt (1965), Bass et. al. (1973), and Springer (1960), and indicate that _C. plumbeus_ eats mostly fishes and crustaceans associated with the epibenthic fauna. The food habits of _C. obscurus_ were similar to those of _C. plumbeus_ and consisted mostly of fishes and epibenthic invertebrates as suggested by Bigelow and Schroeder (1948), and Clark and von Schmidt (1965).

The obvious cranial deformities found in two female _C. plumbeus_ were similar to those reported by Schwartz (1973) for six other specimens of _C. plumbeus_ from the Delaware Bay and Bogue Sound, North Carolina. The cause of these deformities is still unknown.

Figure 1. Primary areas of longline sets during 1974 and 1975

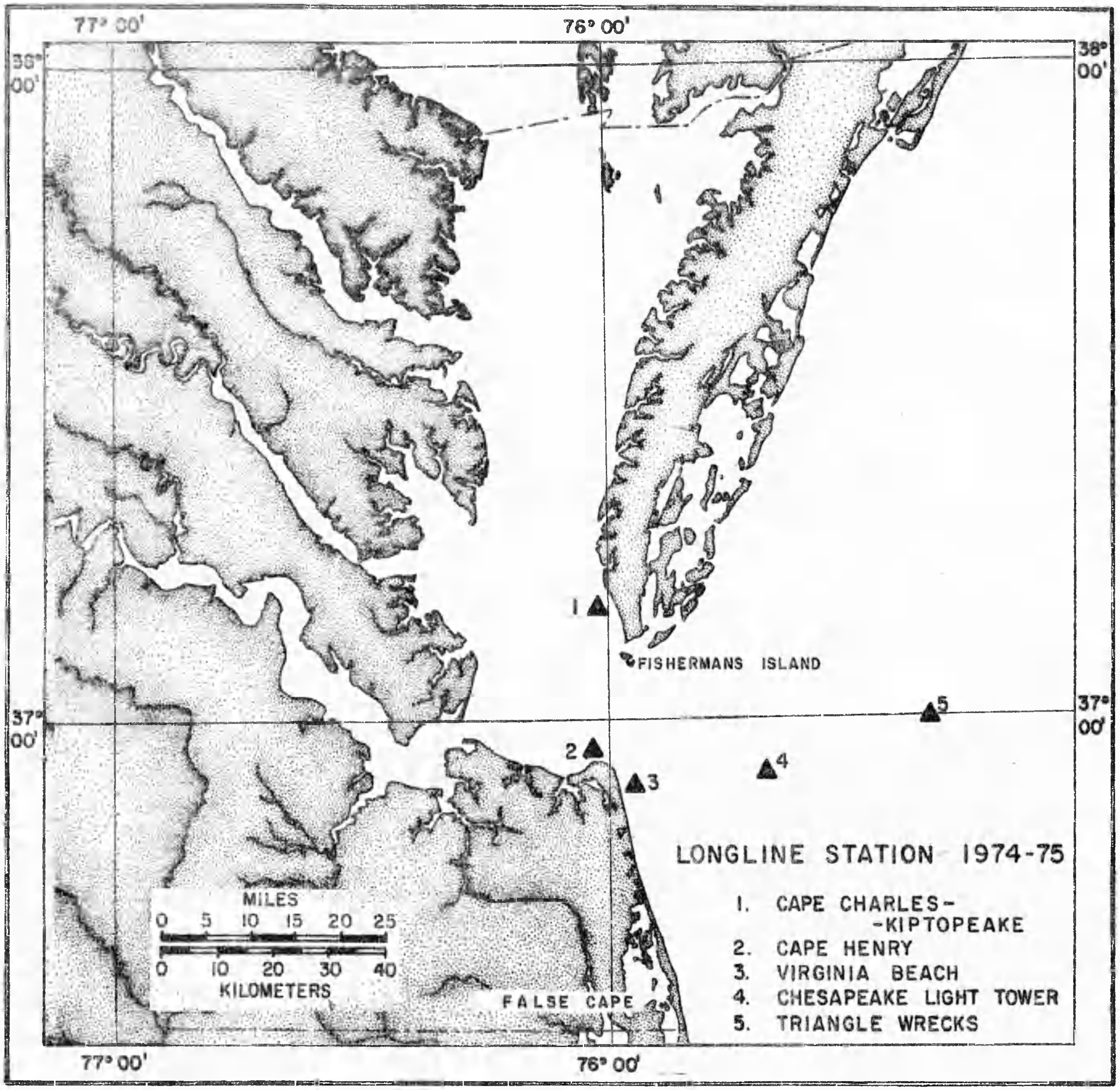
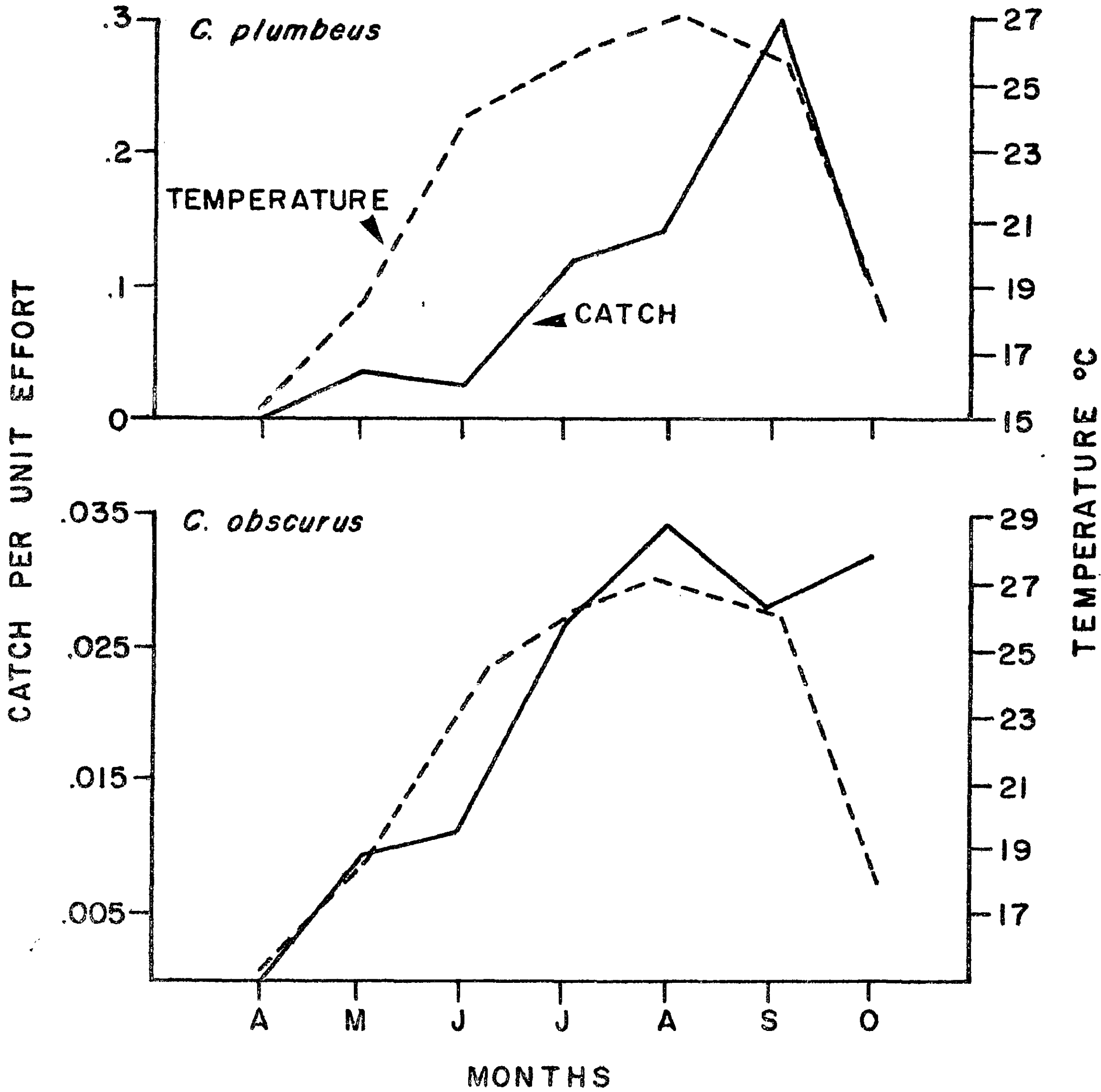

77° 00'
76° 00'
38° 00'
37° 00'
FISHERMANS ISLAND
1
2
3
4
5
FALSE CAPE
MILES
0 5 10 15 20 25
0 10 20 30 40
KILOMETERS
LONGLINE STATION 1974-75
1. CAPE CHARLES--KIPTOPEAKE
2. CAPE HENRY
3. VIRGINIA BEACH
4. CHESAPEAKE LIGHT TOWER
5. TRIANGLE WRECKS

Figure 2. Longline catch per unit effort for *C. plumbeus* and *C. obscurus* pooled for 1974-1975 and plotted by month

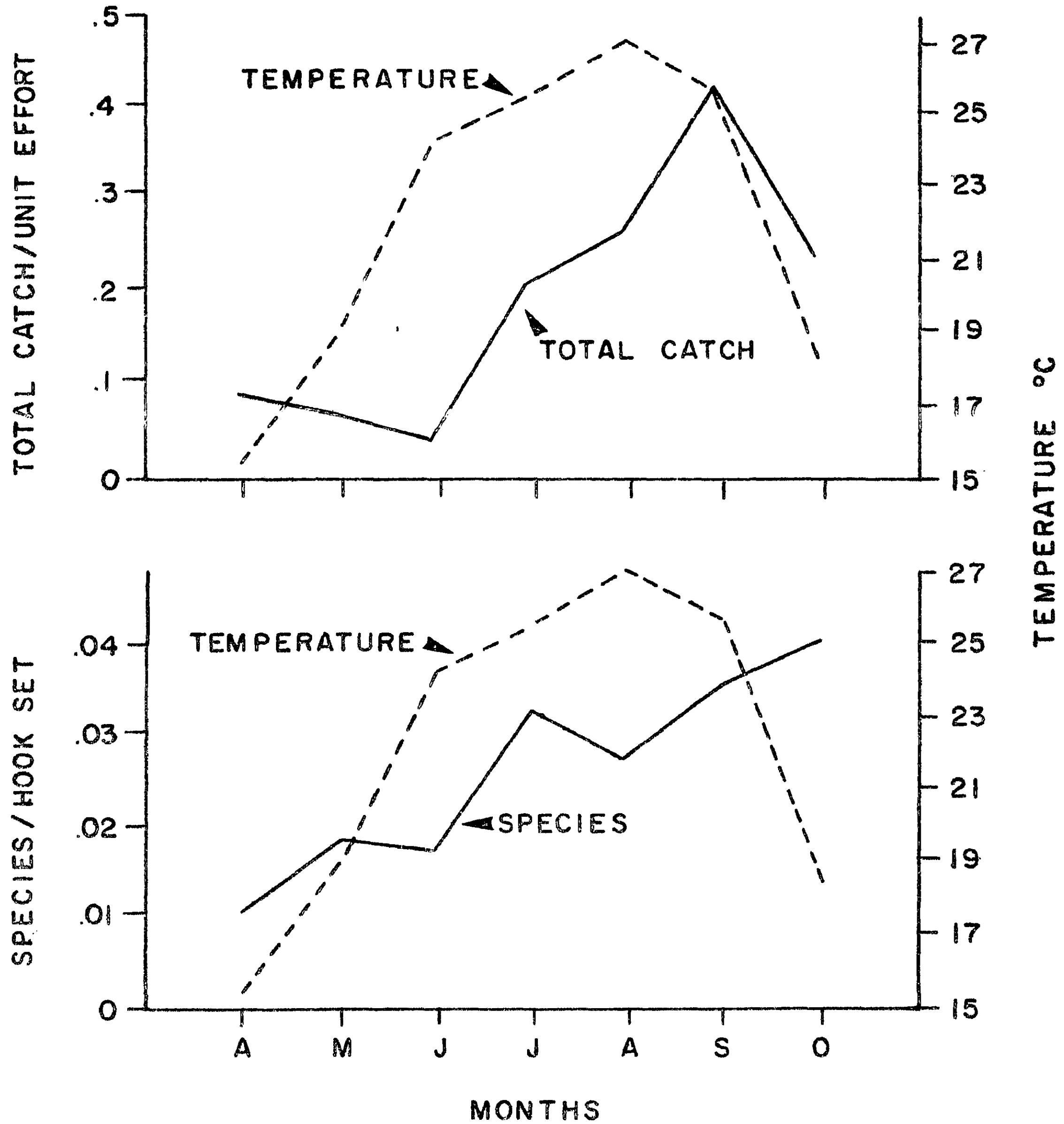


C. plumbeus
TEMPERATURE
CATCH
.3
.2
.1
0
27
25
23
21
19
17
15
C. obscurus
.035
.025
.015
.005
29
27
25
23
21
19
17
CATCH PER UNIT EFFORT
TEMPERATURE °C
A
M
J
J
A
S
O
MONTHS

Total Number Of Sharks Captured on 1260 Hooks Set During 1974-1975

	A	M	J	J	A	S	O	1974 Total	A	M	J	J	A	S	O	1975 Total	74-75 Total
Carcharhinus plumbeus	-	5	3	14	18	11	5	56	-	3	2	19	17	32	9	82	138
Carcharhinus obscurus	-	1	-	7				8	-	1	2	-	9	4	4	20	28
Rhizoprionodon terranovae	-	-	-	6	-	-	-	6	-	-	-	-	1	9	1	11	17
Mustelus canis	8	6	-	1	-	-	-	15	-	-	-	-	-	-	-		15
Carcharhinus limbatus	-	-	-	1				1	-	-		-	11	.		11	12
Carcharhinus falciformis	-	-	-	-	-	-	3	3	-	-	-	-	-	-	5	5	8
Galeocerdo cuvicri	-	-	-	1	4	-	-	5	-	-	-	1	1	-	-	2	7
Odontaspis taurus	-	-	-	-	4	-	-	4	-	-	1	1	-	1		3	7
Sphyrna leweni	-	-	-	1	-	-	-	1	-	-	-	-	2	1	1	4	5
Squalus acanthias	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
TOTAL	8	12	3	31	26	11	8	100	-	4	5	21	41	47	20	138	238

Figure 3. Total catch per unit effort and total number of species per hook pooled for 1974-1975 and plotted by month



TOTAL CATCH/UNIT EFFORT
.5
.4
.3
.2
.1
0
TEMPERATURE
TOTAL CATCH
27
25
23
21
19
17
15
TEMPERATURE °C
SPECIES / HOOK SET
.04
.03
.02
.01
0
TEMPERATURE
SPECIES
27
25
23
21
19
17
15
A
M
J
J
A
S
O
MONTHS

Figure 4. Margalef's index of species richness (D) pooled for 1974-1975 and plotted by month

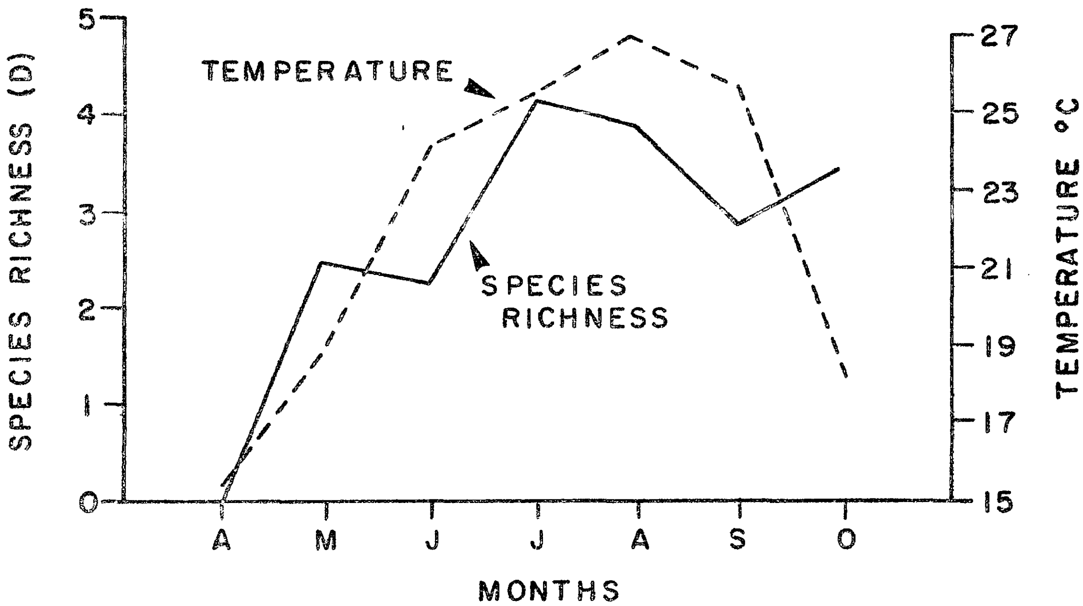

SPECIES RICHNESS (D)
0
1
2
3
4
5
TEMPERATURE
SPECIES
RICHNESS
A
M
J
J
A
S
O
MONTHS
TEMPERATURE °C
15
17
19
21
23
25
27

Figure 5. Size distribution of *C. plumbeus* by long-line stations for 1974-1975. Hatched blocks indicate mature females. (Mature females at station 5 came from a 1976 longline set.)

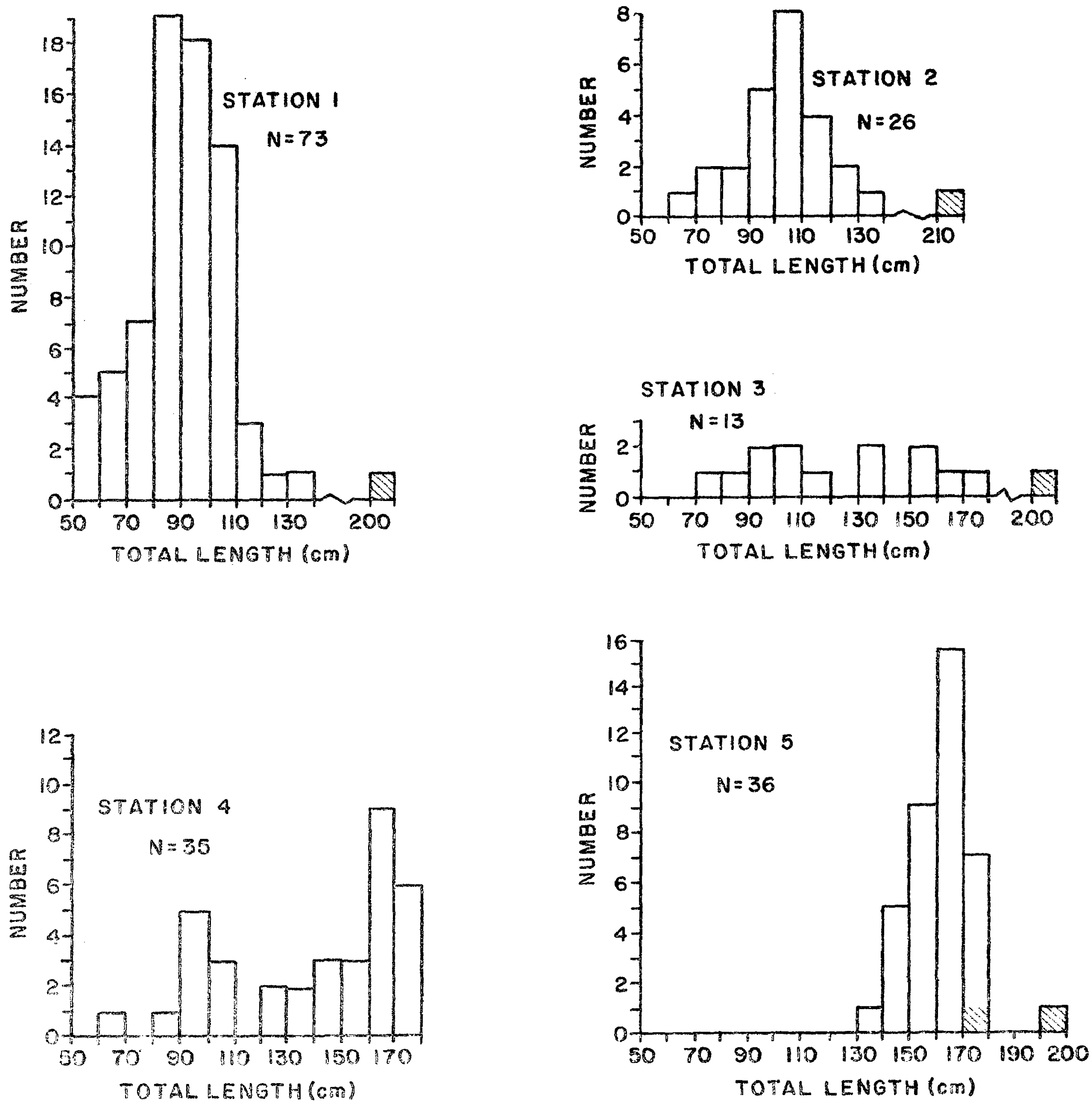
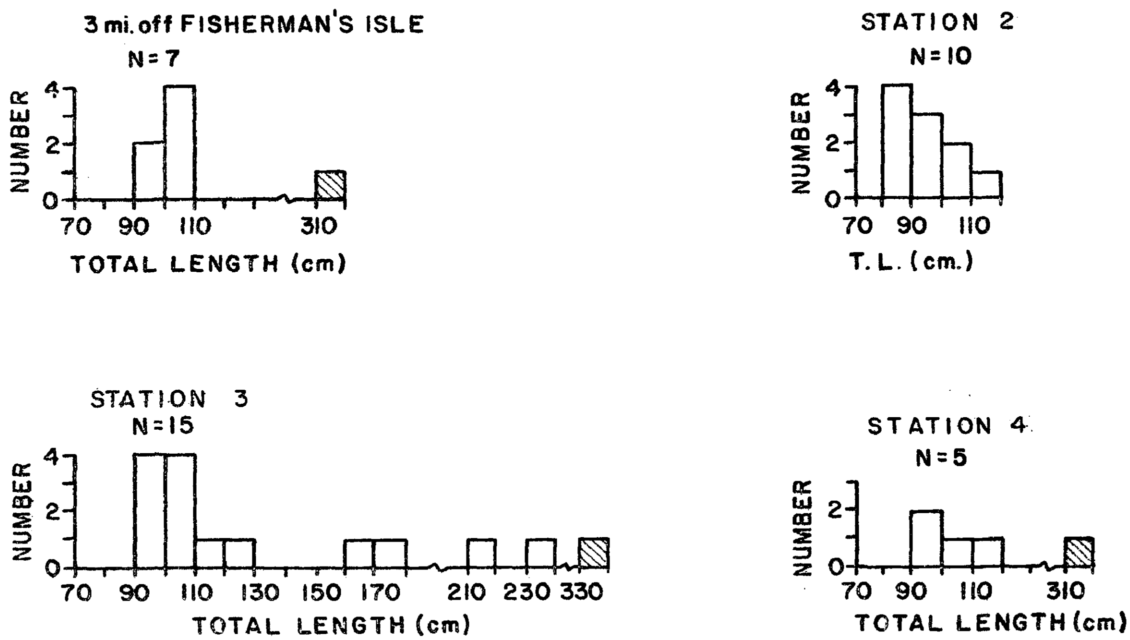

STATION 1
N=73
NUMBER
TOTAL LENGTH (cm)
STATION 2
N=26
NUMBER
TOTAL LENGTH (cm)
STATION 3
N=13
NUMBER
TOTAL LENGTH (cm)
STATION 4
N=35
NUMBER
TOTAL LENGTH (cm)
STATION 5
N=36
NUMBER
TOTAL LENGTH (cm)

Figure 6. Size distribution of _C. obscurus_ by longline stations for 1974-1975 and the 1976 catch 3 miles off Fisherman's Island. Hatched blocks indicate mature females.



3 mi. off FISHERMAN'S ISLE
N=7
NUMBER
TOTAL LENGTH (cm)
STATION 2
N=10
NUMBER
T. L. (cm.)
STATION 3
N=15
NUMBER
TOTAL LENGTH (cm)
STATION 4
N=5
NUMBER
TOTAL LENGTH (cm)

Figure 7. Vertebral sections of _C. plumbeus_ demonstrating annuli for specimens at two (A) and four (B) years.

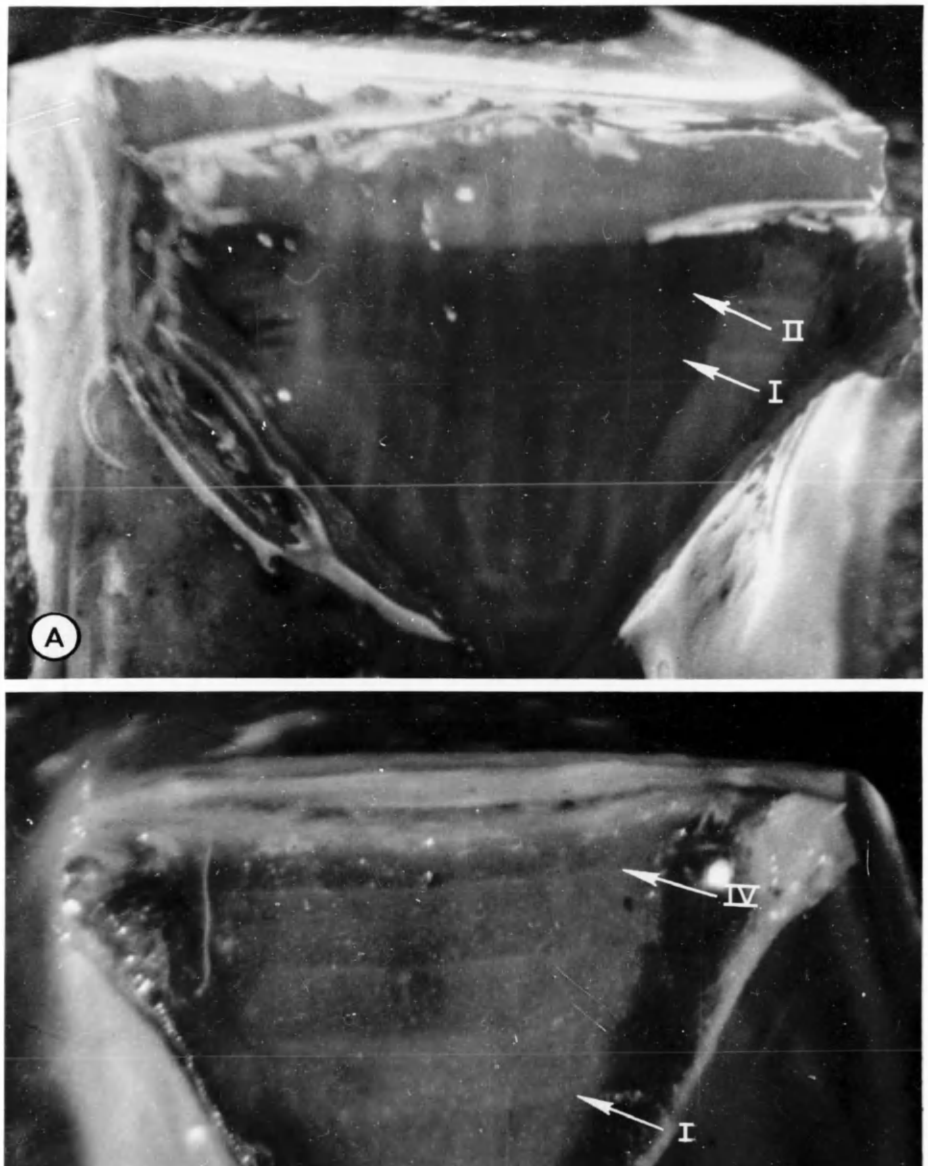

II
I
A
IV
I
B

Figure 8. Vertebral sections of C. plumbeus demonstrating annuli for specimens at seven (A) and fifteen (B) years

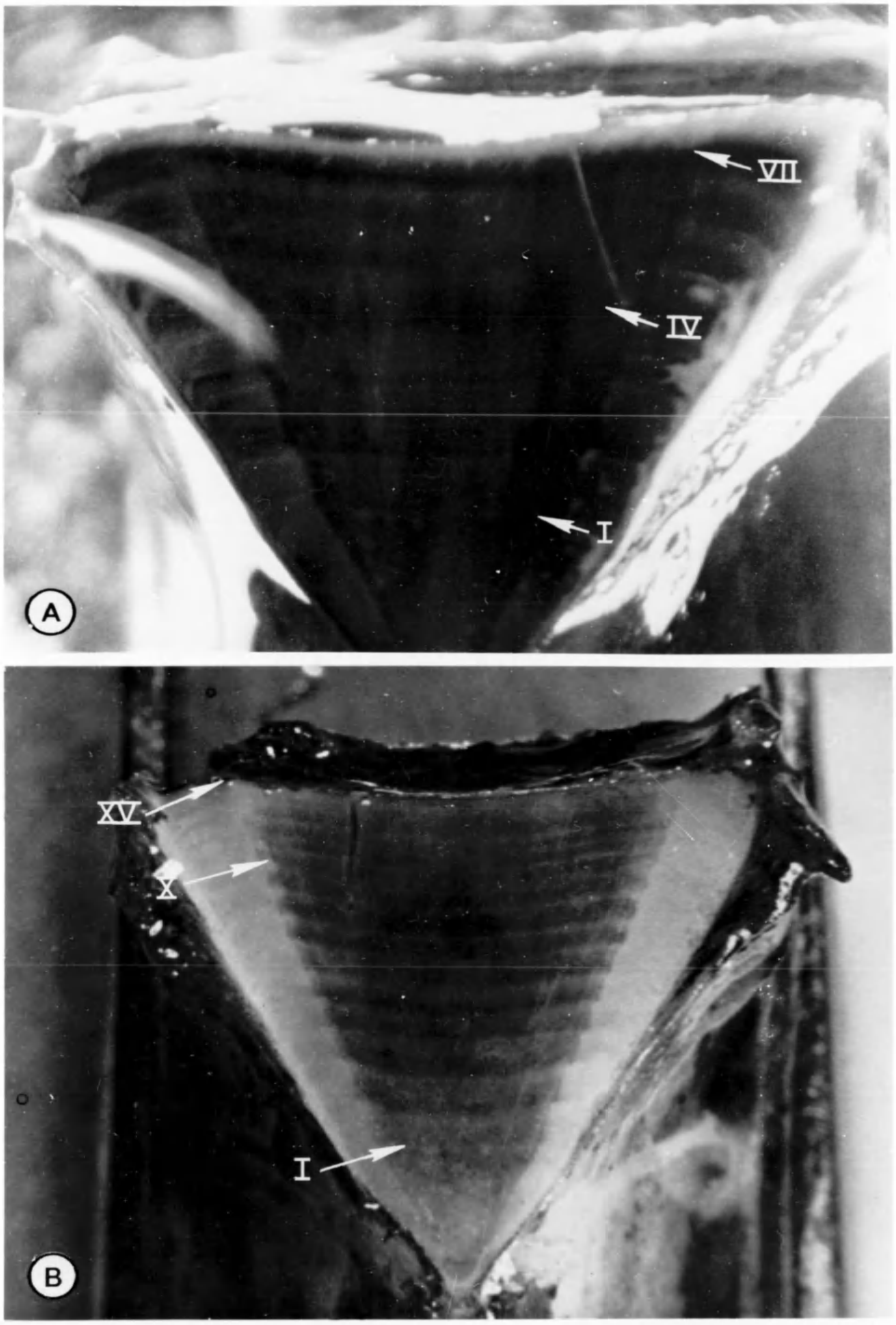
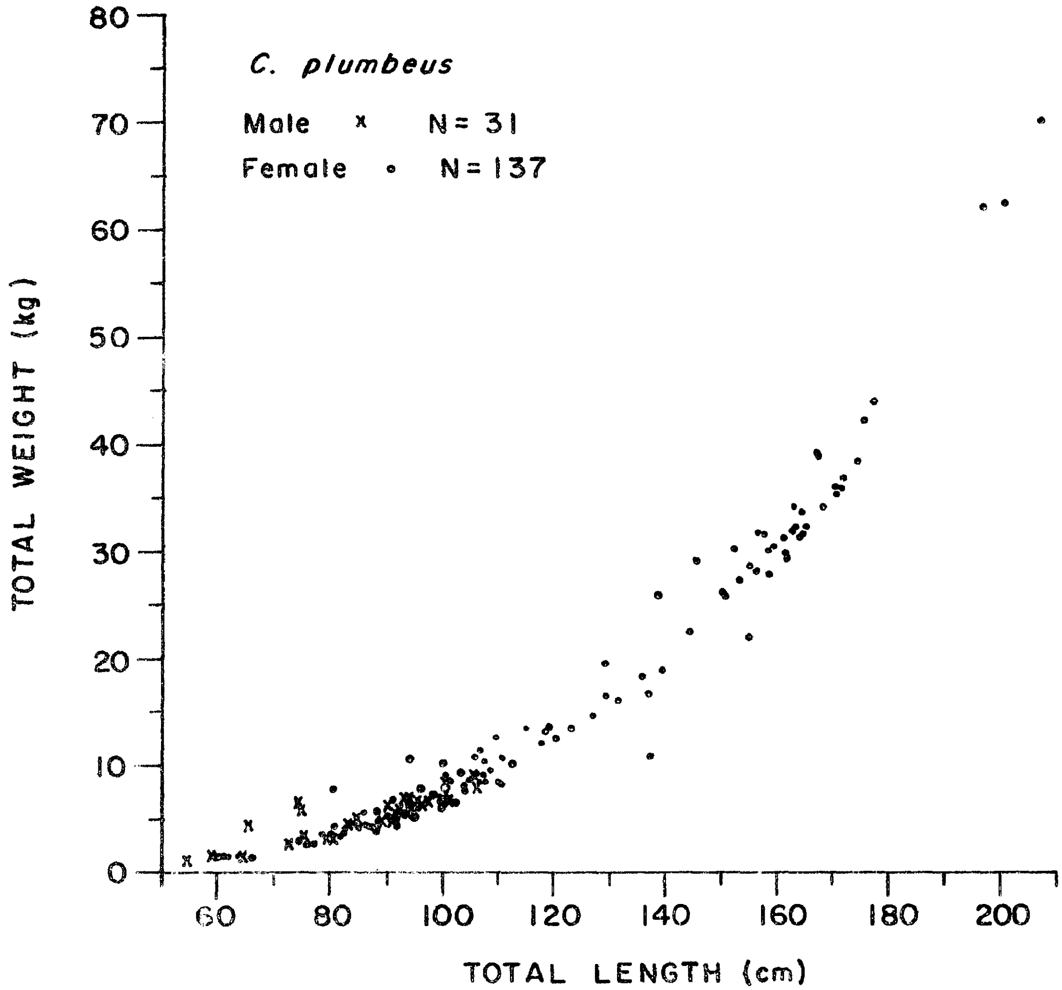

VII
IV
I
A
XV
X
I
B

Figure 9. Weight and length relationship for

C. plumbeus


C. plumbeus
Male x N= 31
Female ∘ N= 137
TOTAL WEIGHT (kg)
TOTAL LENGTH (cm)
0
10
20
30
40
50
60
70
80
60
80
100
120
140
160
180
200

MEASURED AND BACK CALCULATED VALUES FOR FEMALE C. PLUMBEUS

AGE GROUPS

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII
MEASURED RANGE																	
53.7 - 66.0	80.1 - 89.8	74.4 - 99.4	86.3 - 91.4	91.5 - 108.2	95.6 - 113.4	101.6 - 137.5	107.7 - 141.0	127.4 - 136.0	139.1 - 164.2	143.5 - 161.9	153.1 - 163.1	148.9 - 162.9	163.3 - 171.1	164.2 - 177.6	175.2		171.7 - 201.4
AVERAGE LENGTH AT CAPTURE																	
62.4	83.3	84.9	88.3	100.9	105.2	117.9	128.0	131.7	153.0	151.7	158.4	155.8	167.2	168.2	175.2		186.5
NUMBER OF INDIVIDUALS																	
		4		11		9	6	2	4	3		5				0	2
BACK CALCULATED RANGE																	
47.3 - 63.6	63.6 - 76.2	74.2 - 87.6	83.2 - 97.3	92.0 - 107.1	101.8 - 116.5	107.7 - 125.3	117.3 - 135.5	124.4 - 142.6	128.6 - 153.0	133.4 - 150.0	136.6 - 157.2	138.4 - 157.5	157.7 - 164.4	166.4 - 171.0	171.6 - 179.8	183.3	189.5
AVERAGE BACK CALCULATED LENGTH																	
52.8	66.2	78.5	89.0	98.2	106.9	115.3	123.6	131.5	138.3	144.8	149.9	154.6	161.8	168.1	177.1	183.3	189.5
NUMBER OF BACK CALCULATIONS																	
33	78	74	70	65	54	47	38	32	30	26	23	20	15	8	3	2	2

Figure 10. Vertebral sections of *C. obscurus* demonstrating annuli for specimens at zero (A) and two (B) years

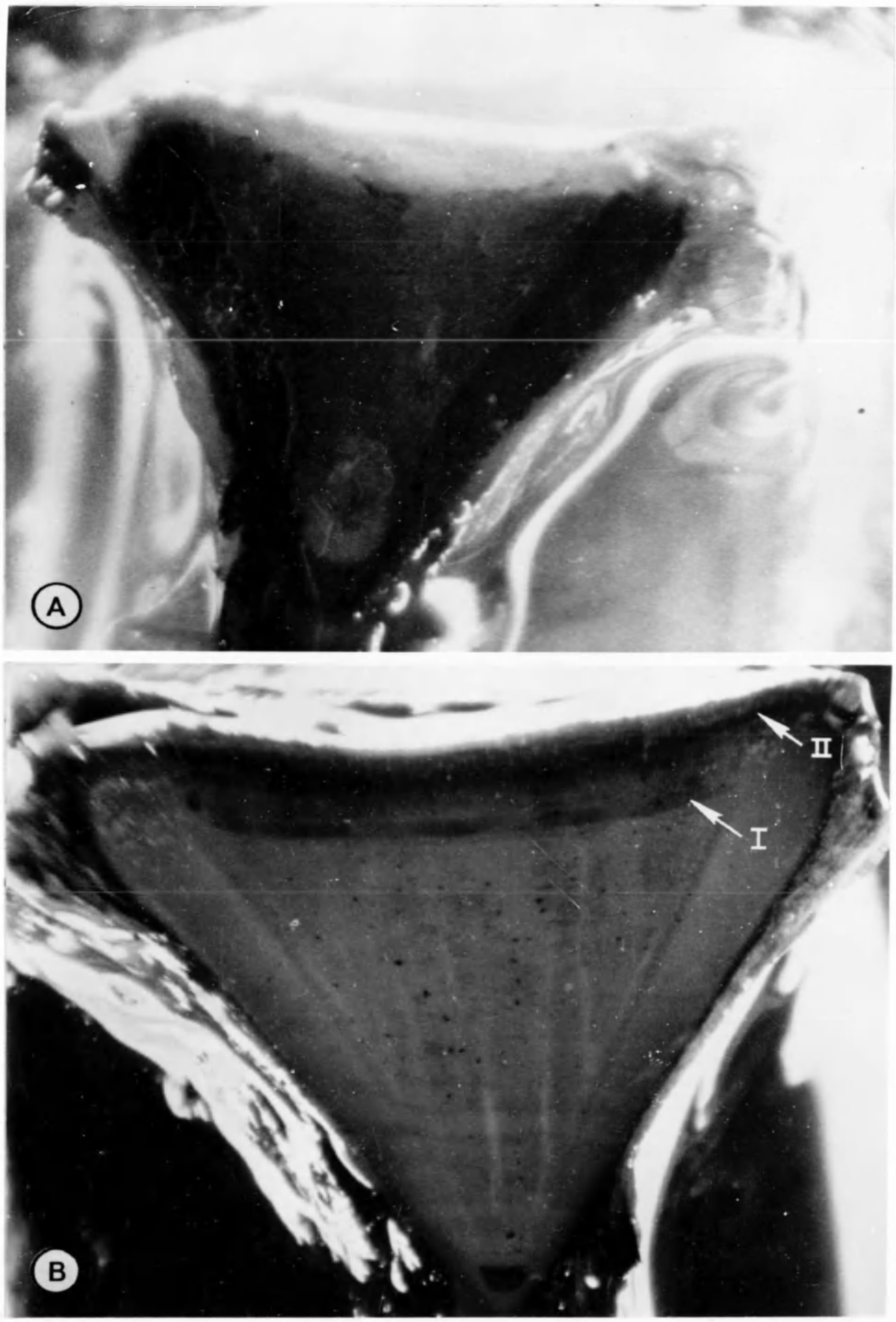
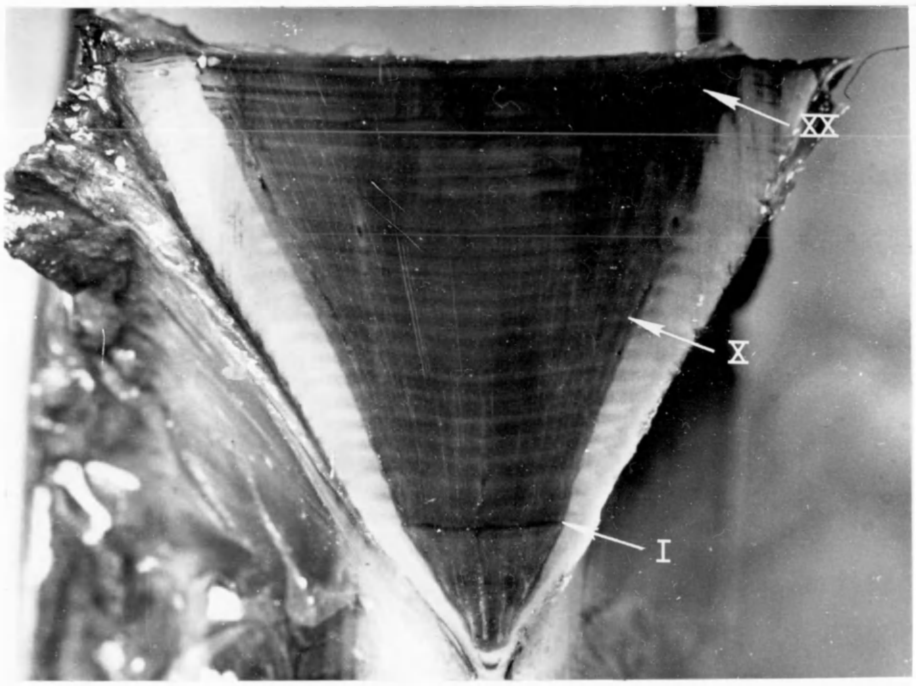

A
B
II
I

Figure 11. Vertebral section of *C. obscurus* demonstrating annuli for a specimen at twenty-three years


XX
X
I

MEASURED AND BACK CALCULATED VALUES FOR FEMALE [illegible]

AGE GROUPS

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
MEASURED RANGE	89.9 - 108.4	98.1 - 114.6	-			-	169.0	175.6	-		-	210.0	-	232.0
AVERAGE LENGTH AT CAPTURE	100.1	106.3	-			-	169.0	175.6	-		-	210.0	-	232.0
NUMBER OF INDIVIDUALS	5	2	0	0	0	0	1	1	0	0	0	1	0	1
BACK CALCULATED RANGE	77.9 - 100.2	97.4 - 106.3	92.2 - 114.2	100.2 - 121.3	105.0 - 137.0	111.4 - 153.0	127.3 - 168.9	133.7 - 172.6	149.7 - 185.0	165.6 - 195.7	180.0 - 202.8	191.1 - 209.9	195.9 - 216.8	202.3 - 231.9
AVERAGE BACK CALCULATED LENGTH	92.4	98.2	106.5	117.0	128.8	140.5	153.9	158.2	163.2	180.7	193.3	202.1	209.0	218.6
NUMBER OF BACK CALCULATIONS	13	8	6	6	6	6	6	5	4	4	4	4	3	3

	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV	XXVI	XXVII	XXVII
MEASURED RANGE	-								315.9	-			-	333.2
AVERAGE LENGTH AT CAPTURE	-	-	-						315.9	-			-	333.2
NUMBER OF INDIVIDUALS	0	0	0	0	0	0	0	0	1	0	0	0	0	1
BACK CALCULATED RANGE	211.9 - 228.0	221.5 - 237.6	235.8 - 253.6	247.2 - 263.2	253.4 - 274.3	259.8 - 283.7	267.7 - 301.5	275.7 - 290.3	290.1 - 315.8	299.6	310.8	320.4	326.9	333.1
AVERAGE BACK CALCULATED LENGTH	220.0	229.5	244.7	255.1	263.9	274.2	284.6	283.0	303.0	299.6	310.9	320.4	326.8	333.2
NUMBER OF BACK CALCULATIONS	2	2	2	2	2	2	2	2	2	1	1	1	-	1

Figure 12. Weight and length relationship for

C. obscurus

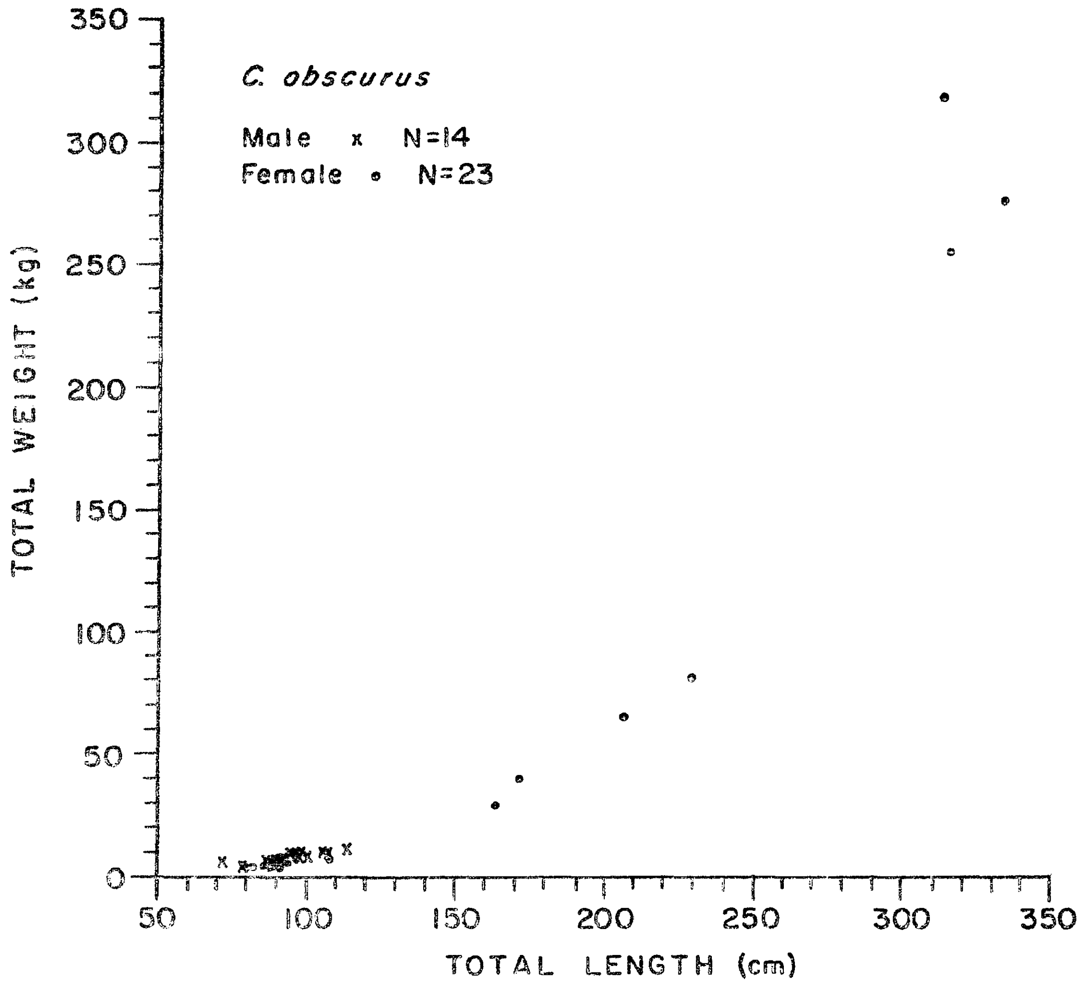
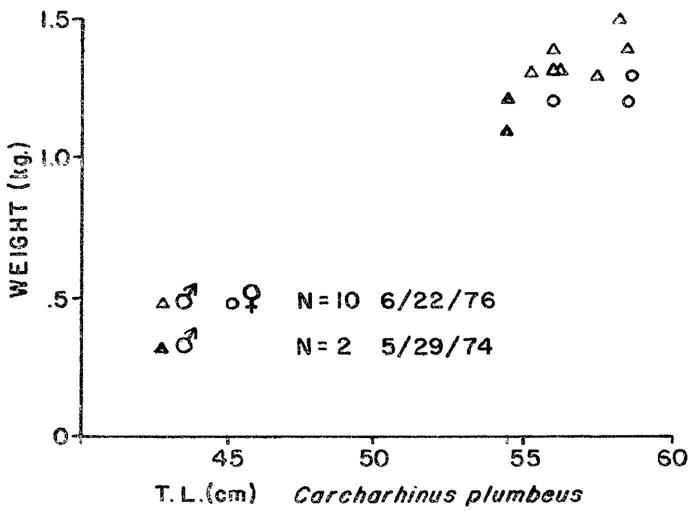

C. obscurus
Male x N=14
Female • N=23
TOTAL WEIGHT (kg)
TOTAL LENGTH (cm)
0
50
100
150
200
250
300
350

Figure 13. Embryo weight and length relationship for *C. plumbeus* and *C. obscurus* litters


1.5
1.0
.5
0
WEIGHT (kg.)
△♂ ○♀ N=10 6/22/76
▲♂ N=2 5/29/74
45
50
55
60
T. L.(cm) Carcharhinus plumbeus

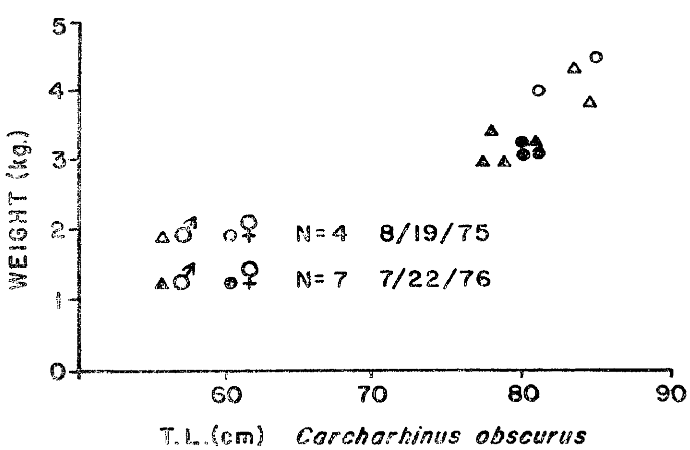

5
4
3
2
1
0
WEIGHT (kg.)
△♂ ○♀ N=4 8/19/75
▲♂ ●♀ N=7 7/22/76
60
70
80
90
T. L.(cm) Carcharhinus obscurus

TABLE 4

FOOD HABITS OF *C. PLUMBEUS*

Number of stomachs containing food item and percent of stomachs in which each food item occurred:

	No. of Stomachs With Item	Percent
Teleost		
Prionotus sp.	8	13
Brevoortia tyrannus	3	5
Astroscopus guttatus	3	5
Anchoa sp.	2	3
Centropristis striatus	2	3
Cynoscion nebulosus	2	3
Mugil sp.	1	2
Leiostomus xanthurus	1	2
Micropogon undulatus	1	2
Hippocampus erectus	1	2
Unidentified pisces	26	42
Bait	29	47
Elasmobranch		
Raja sp.	5	8
Raja eglanteria	1	2
Shark sp.	1	2
Invertebrates		
Decapoda		
Squilla empusa	4	6
Ovalipes sp.	2	3
Callianessa sp.	1	2
Pagurus pollicaris	1	2
Libinia emarginata	1	2
Merostomata		
Limulus polyphemus	1	2
Neogastropoda		
Nassarius trivitattus	5	8
Cephalopoda		
Loligo sp.	3	5

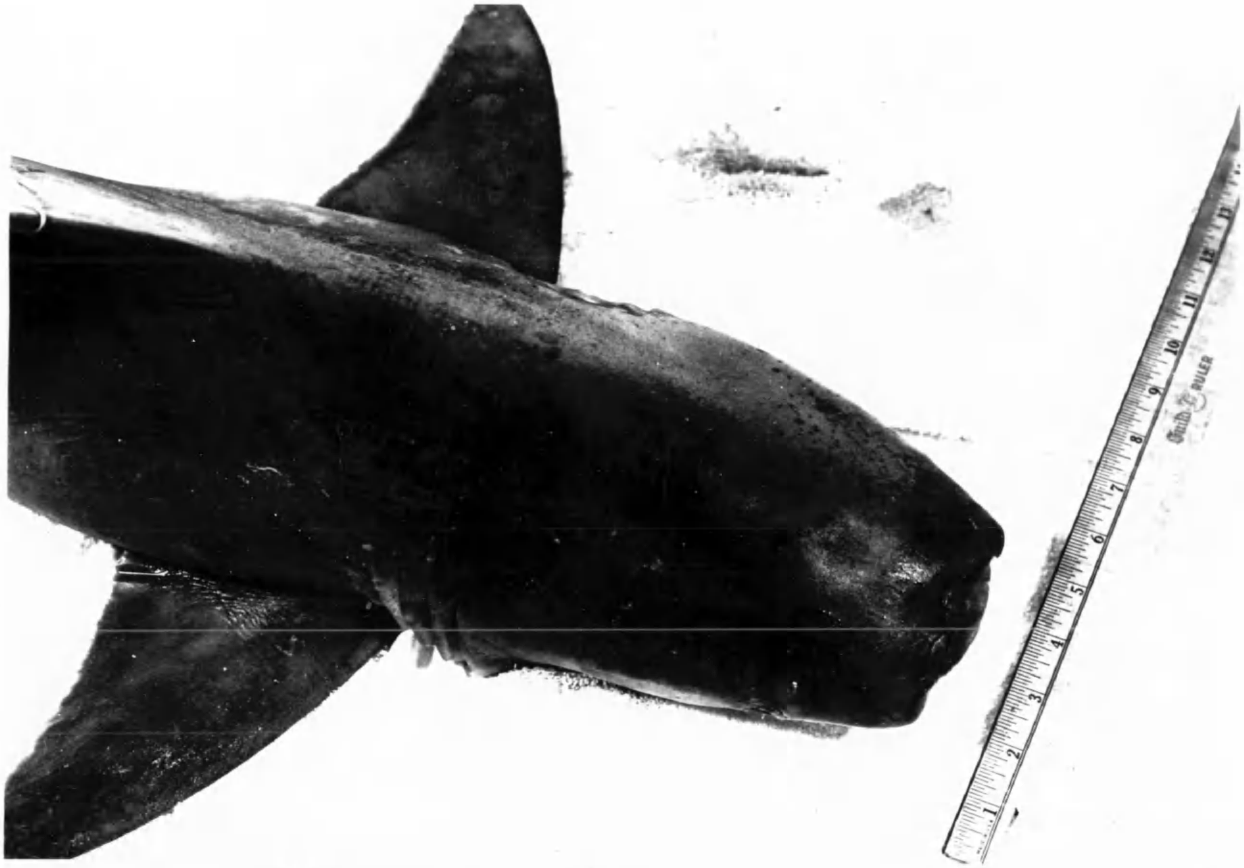
TABLE 5

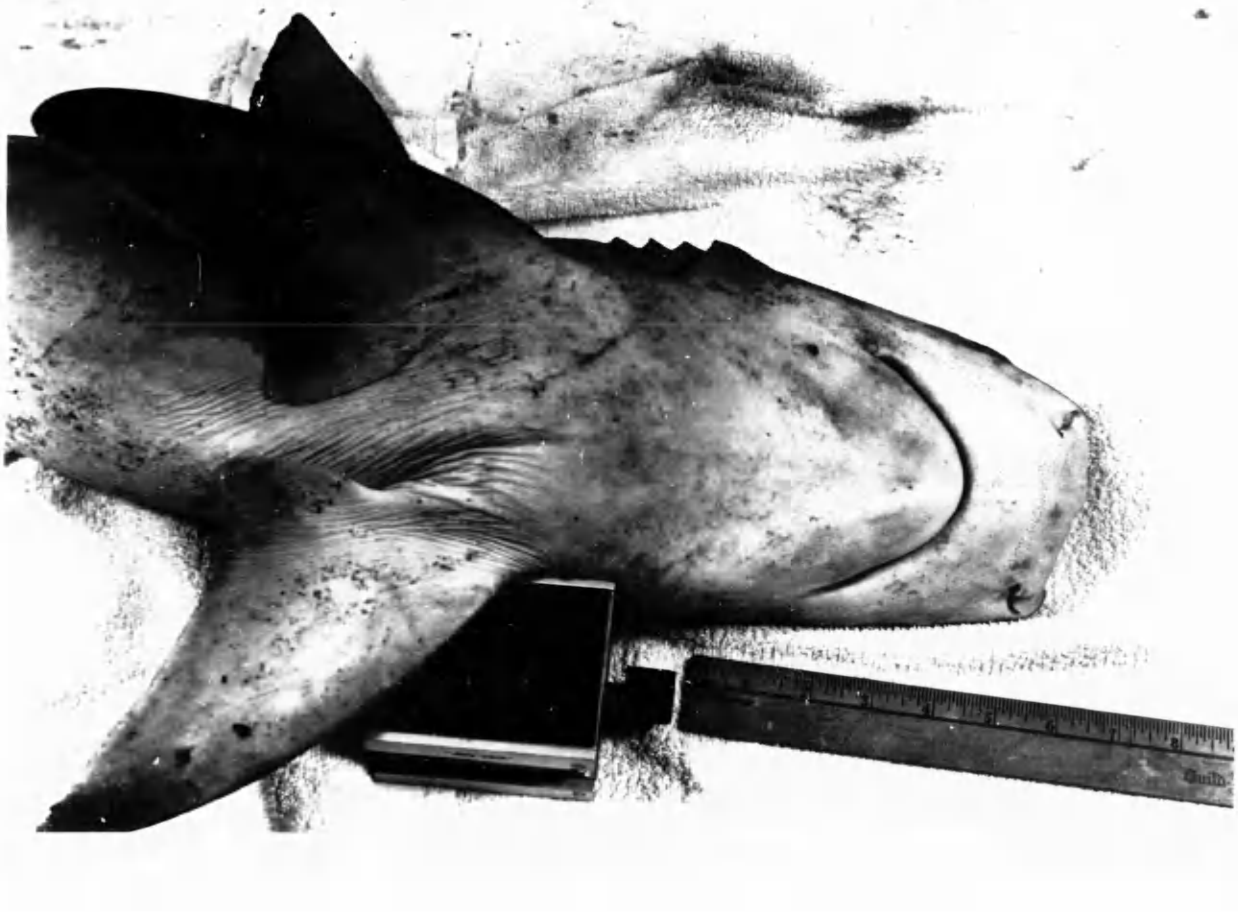
FOOD HABITS OF C. OBSCURUS

Number of stomachs containing food item and percent of stomachs that each food item occurred in:

	No. of Stomachs With Item	Percent
Teleost		
Symphurus plaigiusa	2	12
Prionotus carolinus	1	6
Pomatomus saltatrix	1	6
Leiostomus xanthurus	1	6
Micropogon undulatus	1	6
Unidentified pisces	3	18
Bait	10	59
Elasmobranch		
Raja sp.	2	12
Decapoda		
Ovalipes sp.	2	12
Libinia sp.	1	6
Squilla empusa	1	6
Cephalopoda		
Loligo sp.	1	6

Figure 14. Cranial deformity of a female *C. plumbeus* (VIMS lot no. 03558) captured at Cape Henry





INTRODUCTION TO APPENDIX A

Biological observations on shark species captured during this study other than *C. plumbeus* and *C. obscurus*, are presented in decreasing order of numerical abundance.

APPENDIX A

Rhizoprionodon terranovae (Richarson, 1837) Atlantic sharp-nose:

Seventeen mature male specimens plus one head were captured; whole fish ranged from 81-100 cm TL and 2.4-4.9 kg. Total length-weight relationship is given in Figure 13.

Eighty-eight percent of *R. terranovae* were captured in the Chesapeake Light Tower vicinity and none were taken in the Bay or at the Triangle Wrecks.

Four stomachs were empty or contained bait from the longline. Prey items and percent occurrence in the remaining 13 stomachs consisted of *Leiostomus xanthurus* (37%), *Symphurus plagiusa* (23%), *Loligo* sp. (23%), *Rissola marginata* (7%), *Cynoscion* sp. (7%), *Cancer irroratus* (7%), *Penaeus* sp. (7%), unidentified Pisces (38%), unidentified Crustacea (14%), Gastropoda (7%), Isopoda (14%).

Mustelus canis (Mitchill, 1815) Smooth dogfish:

Biological data was collected from eight females, five of which were pregnant. Total length for the pregnant females was 101-114 cm and 71-86 cm for non-pregnant females. Ovaries of pregnant females contained 10-15 eggs, 1.3-1.7 cm diameter. Average litter size was nine embryos (6-11). Average number of embryos for the right uterus was 4.6 (3-6) and 4.4 (3-5) for the left uterus. One atrophied individual 153 cm TL was observed where sex could not be determined.

Seven stomachs contained prey items and are listed with percent occurrence: Cancer irroratus (57%), Brevoortia tyrannus (14%), Loligo sp. (14%), unidentified Pisces (42%), and unidentified crustaceans (14%).

Carcharhinus limbatus (Muller and Henle, 1841) Spinner shark: Blacktip:

A total of eleven specimens were captured at the Virginia Beach longline station on two consecutive days in August 1975. One mature male was captured in July 1974 at the Chesapeake Light Tower.

The collection included seven males 131-154 cm TL, 13.3-26.7 kg and five females 118-133 cm TL, 10.7-16.6 kg. The smallest mature male was 147 cm TL, 23 kg and all females examined were immature.

Only one stomach was found to contain prey items identifiable only as to Pisces.

Carcharhinus falciformis (Muller and Henle, 1841) Silky:

Eight immature specimens were captured during the October 1974 and 1975 longline sets in the vicinity of the Chesapeake Light Tower. Three males ranged from 107-125 cm TL and 8.6-11.4 kg, whereas five females ranged from 99-129 cm TL and 6.8-14.5 kg.

One stomach contained unidentified shark remains and the others contained only bait.

Galeocerdo cuvieri (Lesueur, 1822) Tiger:

Seven specimens from the Triangle Wrecks and one individual from the vicinity of the Chesapeake Light Tower were examined. Surface water temperatures at the stations were 23-28 C.

Five were females ranging from 160-328 cm TL and 9.2 kg to an estimated 249 kg in weight. The 328 cm female was the only sexually mature specimen. Her flaccid uteri indicated recent parturition.

Three males were immature (ranged 155-206 cm TL and 20.9-46.4 kg in weight).

G. cuvieri had the most varied diet of all the sharks examined. Contents included birds (species?), and loggerhead sea turtle, Caretta caretta, in addition to Cynoscion sp., Centropristis striatus, Pomatomus saltatrix, Leiostomus xanthurus and Aluterus schoepfi. Invertebrates identified were the Decapoda, Cancer irroratus, Calinectes sapidus, Ovalipes quadulpensis, and the whelk (Busycon sp.). In addition to these prey items jetsam and flotsam such as plastic paper, sausage wrappers, and bovine femurs were encountered.

Odontaspis taurus (Rafinesque, 1810) Sand Tiger:

Mature specimens were captured at all but the

Triangle Wrecks longline station. All individuals from the longline sets were mature (males, 199-231 cm TL, 84.8-92.9 kg; females, 197-230 cm TL, 77.1-85.2 kg).

Three males and one female captured at Cape Henry in August 1974 exhibited evidence of recent copulatory activity (Females had highly vascularized cloacal regions, and males were observed rotating their claspers forward and unfolding their tips when they were brought aboard the vessel.)

Two immature male specimens (113 and 125 cm TL) were examined from a haul-seine catch at False Cape in November 1975.

O. taurus had an exclusively piscivorous diet including _Raja eglanteria_, _Brevoortia tyrannus_, _Pomatomus saltatrix_, and _Paralichthys dentatus_.

The parasitic copepod, _Pandarus floridanus_, were collected from the nares, pectoral and pelvic fins. _Odontaspis taurusis_ is a new host record for this species.

Sphyrna leweni (Griffith and Smith, 1834) Scalloped Hammerhead:

Five male specimens ranging from 105-240 cm TL and 7.0-81.6 kg were captured including the first reported specimen of _S. leweni_ (VIMS 03615) in the Chesapeake Bay. The smallest mature male was 170 cm TL and 28.9 kg.

All stomachs of _S. leweni_ contained fragments of _Paralichthys dentatus_ or _Loligo_ sp. or both.

Parasitic copepods (a new host record) obtained from the dorsal surface were identified as Alebion crassus (Copepoda; Caligoide).

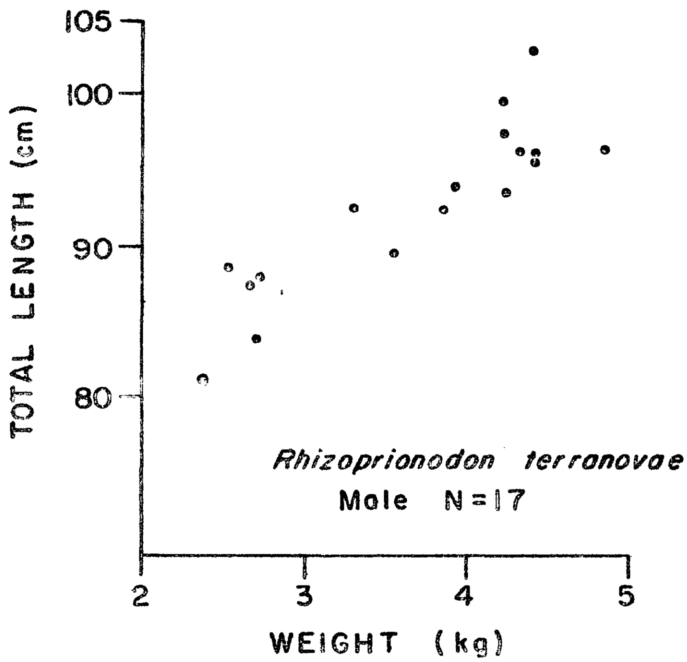
Carcharhinus leucas (Muller and Henle, 1841) Bull Shark:

Two mature male C. leucas were examined: one (223 cm TL, 89.3 kg) from three km off Fisherman's Island in July 1976 (Fig. 1) and one 239 cm TL captured off the mouth of the Cone River, Virginia in 1973. The Fisherman's Island specimen had an empty stomach.

Negaprion brevirostris (Poey, 1868) Lemon Shark:

One mature male (258 cm TL, 84.8 kg) taken off Fisherman's Island in July 1976 contained Brevoortia tyrannus and other unidentified fish remains.

Figure 15. Weight and length relationship for mature male *R. terranovae*



105
100
90
80
TOTAL LENGTH (cm)
Rhizoprionodon terranovae
Male N=17
2
3
4
5
WEIGHT (kg)

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